BOTANY.

Development of the Floral Organs in Aster and Solidago.—The point of growth of the shoot axis becomes very much retarded, and as a result the growing point is transformed into a broad, somewhat elevated disc on which are to appear flowering capitula with centrifugal inflorescence.

The first structure indicating an individual embryonic flower on the receptacle is a hemispherical outgrowth almost perfect in outline and becoming obconical as growth takes place. This embryonic tissue standing on a lateral axis, constitutes the foundation from which arises a differentiation of tissue into special organs. Thus far the path of embryonic development remains the same for all organs, even those of the most various kind. So we have the law of greater structural similarity well worked out in the earlier stages of organisms. From this condition of things on, a new departure is made; the apex of the broad flower axis ceases to grow, while the peripheral portion continues to develop; here we have the first hint of the initial growth of true floral organs. A tubular ring is thus formed and on its peripheral wall small papillæ rapidly arise, giving the structure a cup-shaped appearance with a shallow depression and scalloped margin. This so-called cup elongates, its sinus grows deeper, and the five corolla lobes become sharply defined and are known at once by their shape. Simultaneously with the development of the floral organs in the rising ring, in which there is a complete fusion of all flower parts until liberated, a deep central depression is forming, when ultimately the ovule-bearing portion is placed beneath the rest of the flower parts. Thus we have an epigynous flower with an inferior ovary. However, there are some who would substitute the word hypogynous for epigynous, basing their argument on the theory that all the floral organs, in their initial state, are coalesced in the annular wall; that the appearance of each is due to the liberation of their uppermost parts; that each whorl may appear either in acropetal, or certain whorls, seemingly basipetal, order. The real origin and behavior of the floral organs in their younger stages of development as correlated with the inferior ovary has attracted but little attention, and, therefore, no definite statement can be made as to the true relationship existing between the floral organs in their embryonic condition.

Turning now to the order of development of flower parts, the first foliar structure that appears is a petal. At first they appear as small papillae on the annular wall. In their further development the tissue thickens and the epidermal cells with their rather heavy cell walls become quite large; in later growth their tissue becomes more uniform, and the tips of the five marginal teeth of the corolla-tube turn inward, thus furnishing an excellent protection to the andrœcium and gynœcium. The petals forming the flower tube are not simply contiguous but united, and as the tube elongates it assumes, slightly, the form of a funnel whose upper margin has five spreading teeth. The tubular corolla is not composed of parts originally separate and subsequently united by their lateral margins, for the parts set free are the marginal teeth arising from a common basal tissue; and this tissue develops and elongates *pari passu* with the growth of the nascent organs within.

Almost immediately following the visible corolla, appearing on its inner basal margin, are five minute elevations, the rudimentary stamens. These develop with remarkable rapidity, and their primitive, oval form is soon exchanged for one that is oblong. The histological constituent of the stamen in its early growth is a mass of uniform parenchyma. Presently a new condition arises; a differentiation of tissue into anther lobes and a connective takes place. The fibro-vascular bundle, which is a continuation of that of the flower-axis, though very much reduced, differentiates in the upper part of the stamen, and forms the so-called connective. At the same time there is a modification of tissue which develops into anther lobes; these are connected and yet separated by the connective. In the early process of growth there appear two longitudinal ridges on each half-anther lobe; these answer to the future pollen sacs, and give rise to the archesporium cells, which, usually having but one row in each pollen-sac, again give rise to the squarish mother-cells; in turn the latter yield four pollen grains each. The developmental path, pursued by all pollen grains, is so common that space is of more avail than their further treatment. To give a more complete account of stamineal tissue, mention also should be made of the anther tube. At first the filament develops slowly and the stamens are distinct from one another, but just preceding the unfolding of the flower bud the filament gains length at a very rapid rate by the elongation of its cells; finally the lateral edges of the anthers become coalescent, thus forming a tube, which, when the flower is fully developed, projects beyond the tubular corolla. The anthers do not simply cohere, but unite, for cross sec-

tions show the blending of epidermal tissue; this makes the union complete.

Simultaneously with the origin and development of the stamen, another structure comes into view—the calyx. When first observed there is a bulging out of the epidermal layer in the region of the seeming insertion of the other floral parts. The tube of this outgrowth is not distinguishable from the ovarian wall, but its limb is visible as a tuft of hairs. Primitively, it consists of a short, delicate bunch of hairs, arranged in a circle at the upper extremity of the young ovary. Later, the hairs by rapid growth develop into long appendages, made up of several rows of narrow but extremely elongated cells, the lower ends of which splice into the upper ends of the cells below at the point where the upper end of the cells below turn away from the main trunk, and rapidly taper into an acuminate tip; hence the hair has the appearance of a barbed spear. By its late appearance in development and its epidermal structure some do not regard the pappus as a calyx, while on the other hand others consider it so, though very much reduced in form and structure, the result of the pressure of surrounding bodies.

A little previous to the formation of the pistil another structure may be seen to arise from the receptacle between the individual florets. These foliar bodies, or bracteoles, very much resemble the scale-like leaves of poorly developed vegetative branches. They project quite far between the individual florets; their epidermal tissue consists of very thick-walled, elongated cells surrounding several layers of smaller parenchyma cells.

The next and last of the floral organs to appear is the pistil. About the time when the stamens begin to assume an oval outline and form a constriction near their bases, thereby separating the stamineal tissue into anther and filament, there is detected, on the inner border of the primitive ring in the region of stamineal insertion, an inward growth of cells. This cell tissue gradually develops inward around a common axis until all sides meet, and at the same time elongates in the direction of the flower axis, thus forming the style above and completely overarching the once oval cavity below, changing it to a flask-shaped cavity which is the true ovarian cell. Just at this stage of development it may be mentioned that from now on, the flower parts develop with remarkable rapidity, and finally the flower axis is very much elongated, the gynœcium forming the terminal structure of the flower. The growth of the pistil is somewhat analogous to that of the stamen. As before stated, stamineal growth is partially retarded up to a certain

point, from whence it makes rapid strides by the elongation of the cells of the filament; and for a time the stamen crowns the summit of the flower. So there is a similar phase of growth which characterizes the style; there is a slight cessation of its growth until the anthers begin to shed their pollen, when the style by rapid development pushes its way up through the syngenesious stamens. The lengthening of the style is due to the growth and elongation of the carpellary cells above the ovary. In this case is found a good example of proterandry, which indicates cross-pollination. After the opening of the flower the style lengthens and the pollen is pushed out of the anther tube by the brush-like upper portion of the style as the anthers dehisce. The lines of the stigmatic receptive surface remain intact until that portion of the two-branched style is shoved above the anther tube, whence the two branches separate, curving far back and exposing the stigmatic papillæ on their inner faces; thus the style is made the instrument for disseminating the pollen which it cannot use for itself; as a result, cross-pollination, with almost absolute certainty, is insured.

To speak further of the two-branched style: Two kinds of hairs are detected, viz., stigmatic papillæ and brush hairs. The former are usually short, being either acutely or obtusely tipped, and are confined to the inner faces of the style branches, while the latter are cylindrical, epidermal outgrowths, having various arrangements both on the inner and outer faces of the style-branches. In Aster the style-branches are flattened and linear from their bases to the ends of the two lines of papillæ which line each stigmatic surface. Above the termination of the stigmatic lines are seen brush-hairs which cover both faces of the style-branch. In Solidago the style-branches resemble very much in outline those of Aster. Two stigmatic lines are observed which extend from the base of the branch to a point about one-half the distance to its tip. The brush hairs usually cover the whole outer surface of the branch, and the edges and tip of the inner face above the termination of the stigmatic lines.

It yet remains to speak of the tissue and its modifications that make up the structure of the style. It consists chiefly of ordinary parenchyma, the central portion of which is modified parenchyma, while the upper stigmatic portion is a differentiation of the epidermis into a soft mucilaginous tissue, thus forming a loose conducting mass for the penetration of the pollen tube. In the center of the conducting tissue is also seen a very narrow tubular opening, indicating that it is a continuation of the ovarian cavity. This seems to be constant throughout the species examined. Before concluding, however, the description of

the different floral organs, let the following order of succession as observed in their sequence of development be noted, viz.: corolla, calyx, androecium and gynœcium, although this order of parts does not correspond to Goebel's generalizations on Compositæ. There may be evidences showing a disturbance in the acropetal order of development of whorls, but of necessity the calyx is developed first, and its late appearance, without doubt, is due to the late setting free of its upper portion.

Simultaneously with the development of the ovule appear small, fleshy glands above the ovary at the base of the style; these form a disc, and are supposed to represent an inner row of imperfectly formed stamens.—GEORGE W. MARTIN (in 'The Development of Flower and Embryo-sac in Aster and Solidago").